Space Weather Technical Forecast

Issued on Saturday, 01 June 2024 at 00:13 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: Chance of isolated X-class flares on all days. Chance of G1/Minor, slight chance G2/Moderate geomagnetic storm activity, on Day 1 (01 June). Chance of G1/Minor geomagnetic activity late Day 2 (02 Jun) or early Day 3 (03 Jun).

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity was High, with a peak X1.1 flare from AR3697 at 31/2203 UTC. This region has also produced an M1.0 flare earlier in the UTC day. There are now seven sunspot regions on the visible disc. The largest and most complex region on the disc remains AR3697 in the southeast. It has shown growth of intermediate spots in the last 24 hours, and the strong delta configuration remains. It has a complex magnetic configuration along with some magnetic looping above the sunspot. AR3691 in the north centre disc is the other group of note on the disc, although it has started to fade in the last 24 hours and the delta configuration is no longer visible. AR3698 in the northeast has shown growth recently, and is starting to develop penumbra. The other sunspot groups on the disc are small, simple and appear stable at this time.

A dimming was observed to the south of AR3698 on SDO 211 imagery around 31/0419 UTC, not long after a C7.5 flare from the same region. A very faint partial halo CME was observed on coronagraph imagery around 31/0800 UTC, with analysis suggesting a glancing blow at Earth late on Day 2 into Day 3 (02-03 Jun), albeit with low confidence.

Solar Wind / Geomagnetic Activity: Solar winds, as observed by ACE at L1, showed evidence of a couple of weak transients during this period. Wind speeds were at background levels, between 330-370 km/s. The density was initially average to above average, with a peak of 32ppcc at 31/0411 UTC. It fell to below average from around 31/0800 UTC. The Interplanetary Magnetic Field, Bt, was generally weak, with a moderate interval between 31/0100-0300 UTC, peaking near 10nT. The north-south component, Bz, was predominately negative, ranging between +1/-8nT. Phi angle was generally negative (towards the Sun), but did vary at times. Geomagnetic activity was Quiet to Active (Kp 2-4).

Energetic Particles / Solar Radiation: High energy proton flux at GOES18 (greater than 10 MeV) remained at background levels with no solar radiation storms occurring. High energy electron flux (greater than 2MeV) at GOES16 varied between background and moderate levels. Associated 24-hour fluence remained below the Active threshold. Observed fluence at 01/0000 UTC was 1.78e6 integrated pfu.

Four-Day Space Weather Forecast Summary

Solar Activity: Moderate activity is expected, with a chance of isolated X-class flares throughout the period. AR3697 in the southeast, and perhaps AR3691 in the north-centre disc, provide the bulk of the current flare risk.

Solar Wind / Geomagnetic Activity: A CME that left the Sun on 29 May may give a glancing blow at Earth on Day 1 (01 June). Solar winds are likely to persist at background levels through

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Days 1 and 2 in the absence of any potential CME arrival. A small positive coronal hole in the northwest disc could give a modest enhancement from late Day 1 or Day 2 (01-02 June), with winds peaking at slightly elevated levels. A faint CME from close to the AR3698 region may give a glancing blow late on Day 2 into Day 3 (02-03 Jun).

Geomagnetic activity is expected to be mainly Quiet to Unsettled initially on Day 1, perhaps Active under weak transient influence. Any arrival of the 29 May CME could see activity increase to G1/Minor Storm levels with a slight chance of G2/Moderate Storms through Day 1. On Day 2, there is a slight chance of peak G1/Minor Storm conditions resulting from minor coronal hole and possible residual CME influence, otherwise activity should be at Quiet to Unsettled levels, before potentially rising again late Day 2 into Day 3 to G1/Minor Storm conditions if the second CME glance arrives. Activity then easing back to Quiet by Day 4 (04 Jun).

Energetic Particles / Solar Radiation: High energy proton flux is likely to persist at background levels, with a slight but increasing chance of rising above the S1/Minor Storm threshold given any further notable flares. High energy electron flux (>2MeV) is forecast to remain at background to moderate levels on all days, with the associated 24 hour fluence forecast to remain below the Active threshold.

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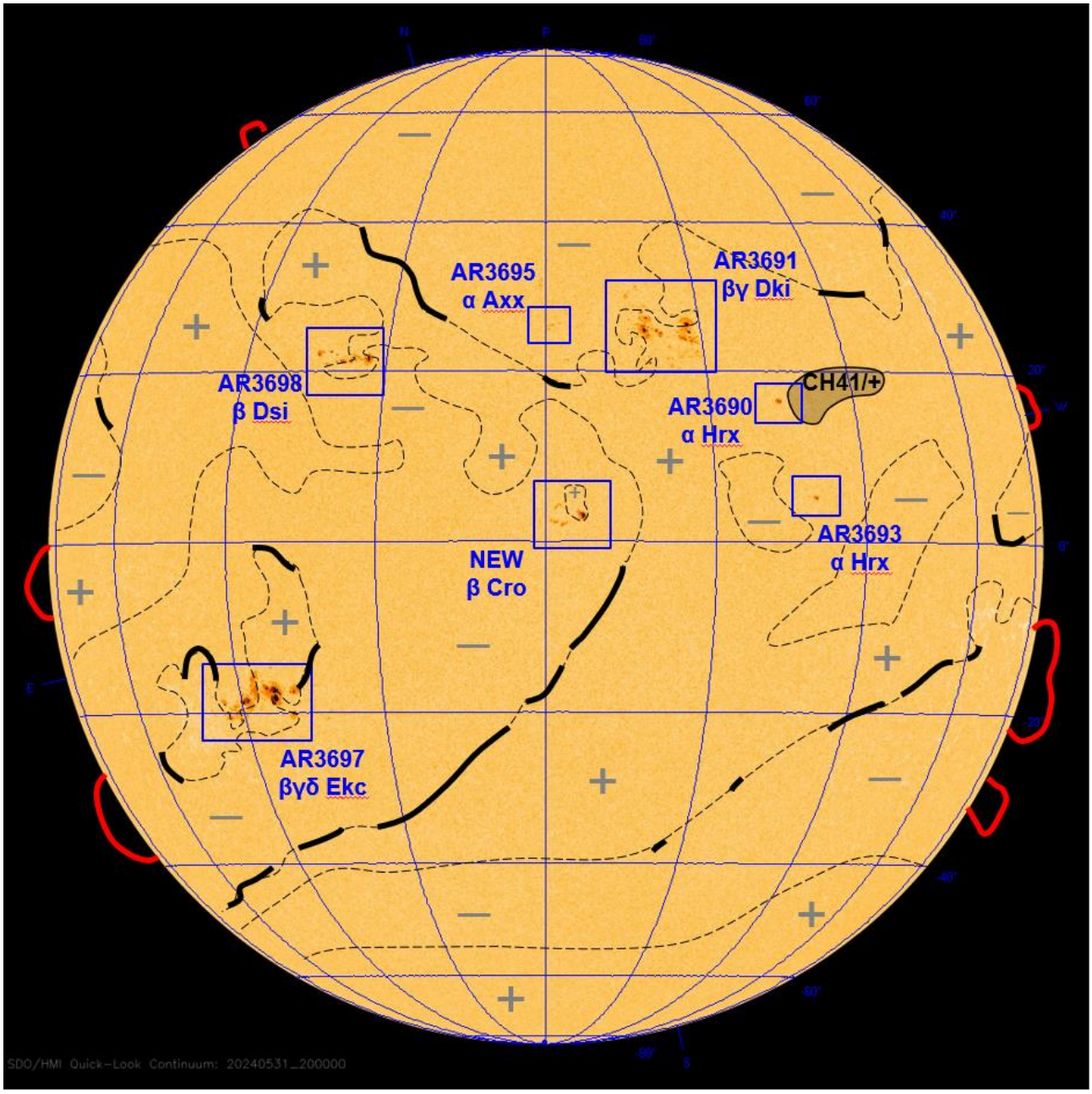
Figure 1. Solar Analysis Valid 31/2000 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

A CME that resulted from the X1.4 flare of AR3697 on 29 May has been modelled as a potential glancing blow at Earth on Day 1 (01 June), although the bulk of the ejecta is expected to pass behind Earth's orbit. Confidence in the fit of this feature to coronagraph imagery is moderate given a partial data gap in the hours immediately following the eruption, therefore there is some uncertainty in the arrival time.

A very faint partial halo CME was observed on coronagraph imagery, possibly as a result of a C7.5 flare from the AR3698 sunspot region and then subsequent dimming to the south of this region, as observed on SDO 211 imagery. Analysis proved tricky due to the very faint nature of the CME on available imagery, with a suggested glancing blow possible at Earth late on Day 2 into Day 3 (02-03 Jun), however confidence is low.

A number of large filaments currently occupy the near centre-disc region of the Sun. Should any of these erupt in the coming days there is a likelihood for ejecta to be Earth-directed, so these regions will be closely monitored for any developments.

Solar winds are likely to persist at background levels at first in the absence of any potential CME arrivals. Small coronal hole CH41/+ in the northwest disc could give a modest enhancement from late Day 1 or Day 2 (01-02 June). This is a recurrent feature from the last rotation, but much changed, appearing significantly smaller and therefore likely to be less strong than the maximum (550km/s) speeds observed in early May. Any connection to this feature should see speeds peak at slightly elevated levels on Days 2 or 3 (02 or 03 June).

Geomagnetic activity is expected to be mainly Quiet to Unsettled initially on Day 1. Any arrival of the 29 May CME could see activity increase to G1/Minor Storm levels with a slight chance of G2/Moderate Storms through Day 1. On Day 2, there is a slight chance of peak G1/Minor Storm conditions resulting from minor coronal hole and possible residual CME influence, otherwise activity should be at Quiet to Unsettled levels. If the second CME arrives later Day 2 or early Day 3 (02-03 Jun), then activity could increase once again, perhaps to G1/Minor Storm Conditions, before easing once more by Day 4 (04 Jun).

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	40	30	30	5
Strong	G3	No	5	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

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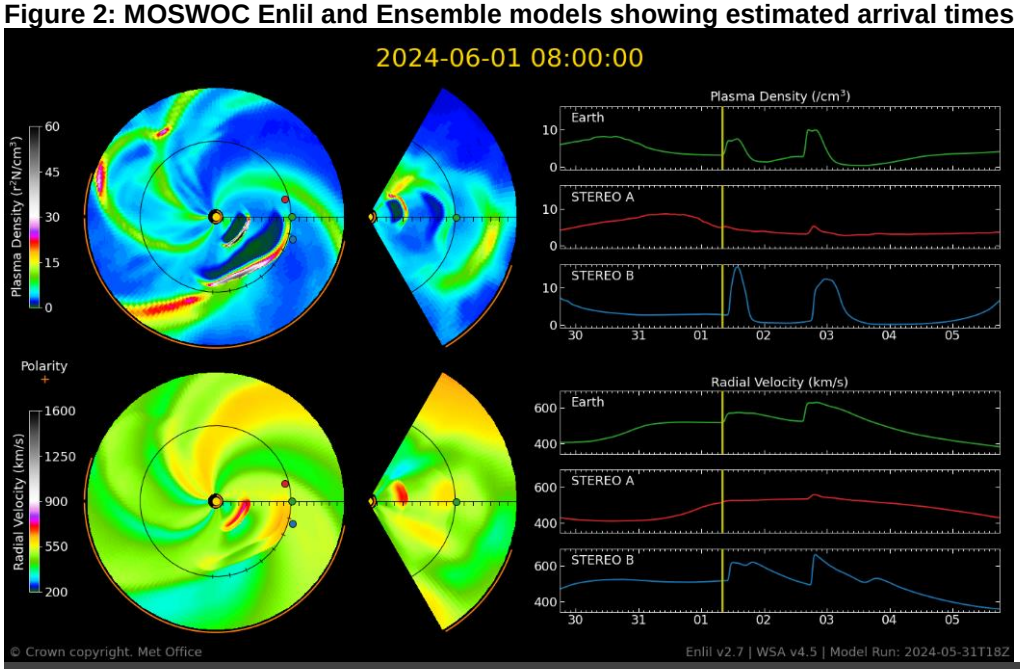
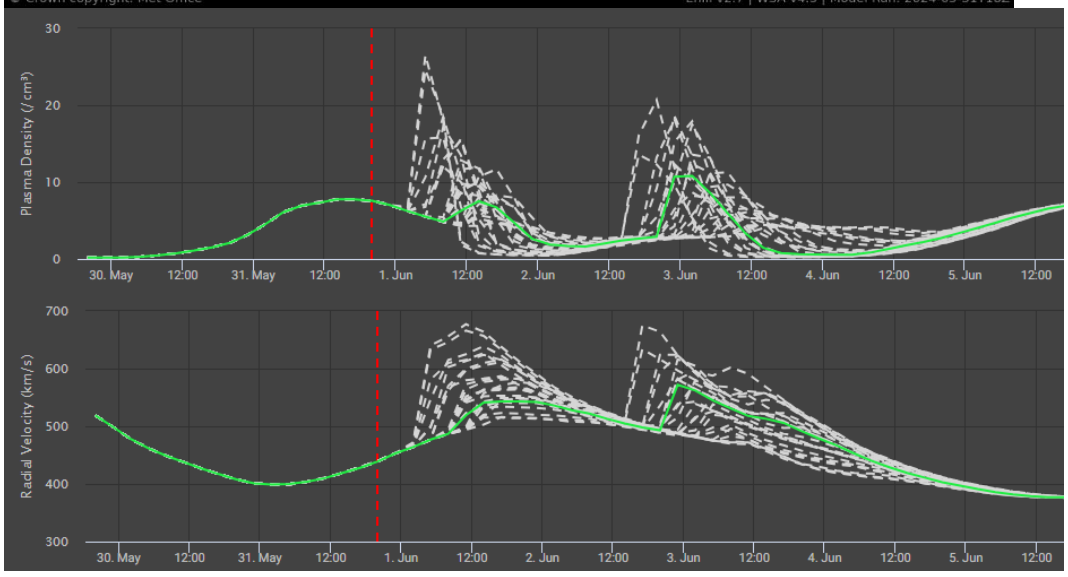
Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
29/2008	Partial	X1.4 flare from AR3697	SE	647 km/s	01/0800 UTC	Moderate confidence in timing and impacts. Glancing blow most likely.
31/1115	Partial	C7.5 flare from AR3698 and assoc. dimming.	NE	900 km/s	02/1600 UTC	Very faint CME making analysis tricky. Low confidence glancing blow.

Figure 2: MOSWOC Enlil and Ensemble models showing estimated arrival times of CMEs.





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Radio Blackouts - X-Ray Flares:
There are now seven sunspot regions on the visible disc, with a new, as yet unnumbered, region developing in the north-centre disc. The largest and most complex region on the disc remains AR3697 (Ekc/Beta-Gamma-Delta) in the southeast. It has shown some growth of intermediate spots in the last 24 hours, and the strong delta configuration remains. It has a complex magnetic configuration along with some magnetic looping above the sunspot, and was responsible for the largest flare of the period, an X1.1 peaking at 31/2203 UTC. AR3691 (Dki/Beta-Gamma) in the north centre disc is the other group of note on the disc, although it has started to fade in the last 24 hours and the delta configuration is no longer visible. AR3698 (Dsi/Beta) in the northeast has shown growth recently, and is starting to develop penumbra. The other sunspot groups on the disc are small, simple and appear stable at this time.

M-flares are expected, with a chance of isolated X-class flares, these most likely from AR3697 and perhaps AR3691.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	75	75	75	75
Very Active	R3 to R5 X Class	Yes	30	30	30	30

Figure 3: GOES 16 & 18 X-ray flux.

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Solar Radiation Storms - (High Energy Protons):
GOES-18 proton flux is likely to persist at background levels, with a slight but increasing chance of rising to the S1/Minor Storm threshold given any further notable flares. These are most likely from either AR3697 in the southeast, or AR3691 in the north-centre disc. This risk will increase in the coming days as both regions continue to transit westwards into more geoeffective longitudes on the visible disc.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	15	15	20	25
Very Active	**≥ S3 ***	No	1	1	1	1

* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)

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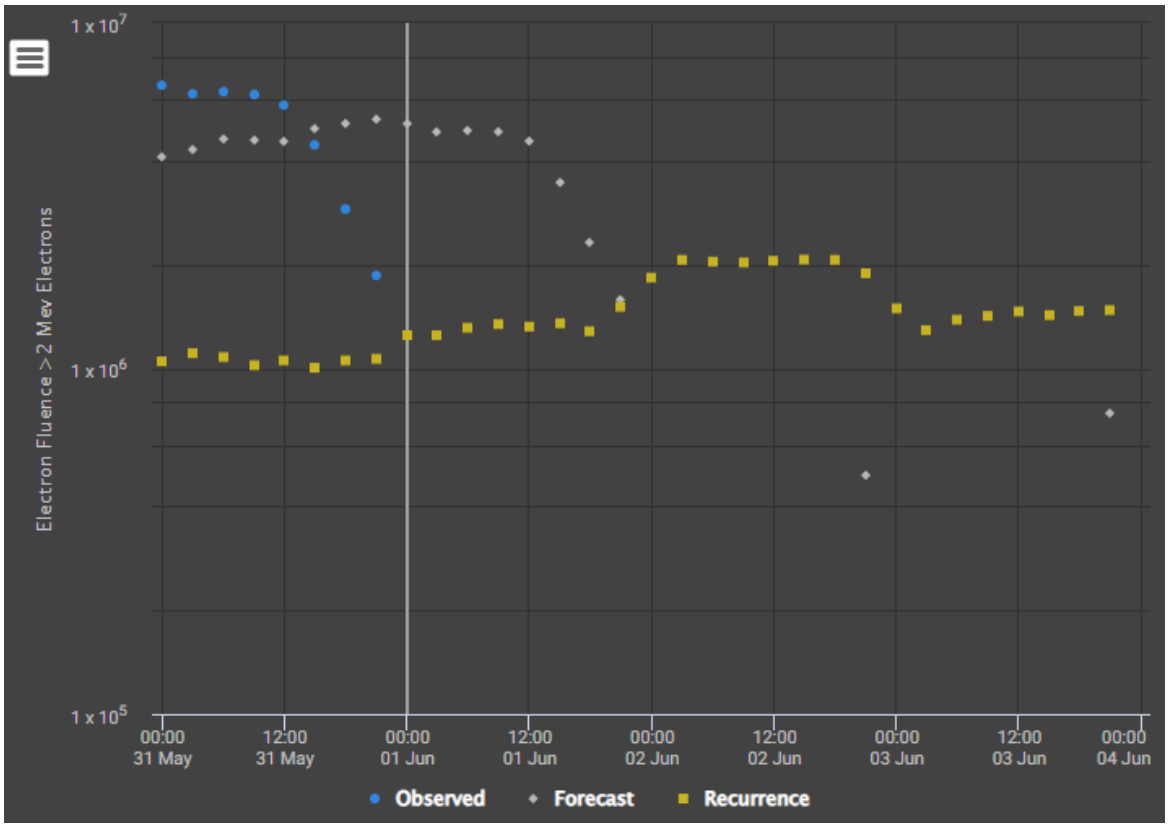
High Energy Electrons Event (≥ 2MeV):
GOES-16 electron flux is expected to remain at background to moderate levels on all days, with no significant sources of enhancement anticipated given only modest CME and coronal hole influences in the forecast. The associated 24 hour electron fluence is expected to remain below the Active level, as supported by MOSWOC REFM, which is giving reasonable guidance for the expected trend through the period.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	1	1	1	1
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

Figure 4: MOSWOC REFM model.



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